Sampling and Dividing of Bulk Materials

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Summary

The quality control of a product during initial, intermediate and final stages of production is best achieved with accurate sampling and sample division. It is of great importance that the sample taken is representative of the whole. The result of the quality determination of the sample is often the basis for a decisive production or economic decision.

This report gives a summary of the various sampling possibilities and the individual machines available for sample dividing.

1. Sampling Schemes

1.1 Time-Proportional Sampling

The interval time of the sampling is governed through a timer. The sampling time is not related to flow rate, so the quantity of each sample could be different. The process is easy to maintain and inexpensive to operate. These devices are inexpensive to install and are generally of rugged construction.

1.2 Weight-Proportional Sampling with Variable Sample Quantity

With this method the sampling machine receives an impulse from a belt weigher after it senses a pre-set weight (e.g. 50 tons), the sampling machine will then take a sample. Each sample is different in quantity, as in 1.1, as the quantity of product passing the sampling point is variable. The composition of the sample could therefore be different if the flow rate were changed. This method is also easy to maintain and inexpensive, because in most cases the customer already has a belt weigher and requires only the sampling apparatus.

1.3 Weight-Proportional Sampling with Constant Sample Quantity.

This sampling system, as in 1.2, is governed by a belt weigher, but in addition the sampling timer can be changed with a relay. The sampling time changes in relation to the volume of material passing the belt weigher. This could result in a bulk sample made up of 100 individual subsamples which gives one final complete sample made up of 100 representive components. This scheme gives the best results. The technical maintenance, however, requires careful control and this system can be subject to breakdowns because of the electrical and electronic control equipment required. It is also a comparatively expensive system to install.

If we compare the three systems described it is found that only minor errors are present in each. It is found in practice that for most applications, the sampling system described in 1.1. is sufficiently accurate.

2. Sampling Machines

Requirements of sampling machines:

a) Compact construction.
b) Low wear and tear.
c) High machine safety.
d) Ease of cleaning.
e) Low cost.
f) Low maintenance cost.
g) Low alteration or influence on the particle size and quality of material being sampled.

2.1 Sample Collection

For the efficient sampling at a conveyor belt discharge point the sample collector must pass through the entire product stream. It is important that all parts of the stream should be traversed at the same speed. The sampling collector must pass completely through the stream of falling particles and must not remain in the particle stream in the parked position. The speed must be adjusted so that all particles, whatever their size enter the sampler so that a representative sample is taken.

Width of the sample collector:

If the width of the sample receiver is too narrow it is possible that the larger particles could rebound from the edge of the collector and pass back into the main product stream. The sample would be therefore non-representative. Normally we advise our customers that the opening must be between 2.5 and 4.5 times larger than the largest particles of the bulk material. Experience has shown us that, generally, a minimum of three times the largest sample particle is satisfactory. If, however, one needs to sample material with a small particle size such as sand of 0.5 mm diameter, then we cannot use the three-times-rule as a slit width of 1.5 mm is impractical. Experience has shown that an opening of approximately 10 mm is required, as a minimum.

Speed of the sampling machine:

If the traversing speed of the sample chute is too high one has the same problem as above where material would bounce away from the edge of the chute and not be properly collected. Our experience has shown that a traversing speed of up to 0.8 m/s is satisfactory.

Motive power for the sampling machine:

a) Sample collector must be driven at a constant speed. We normally advise customers to use electric motors for the drive. The motor must have a constant speed before the sample is taken.
b) The motor speed must not vary with load, i.e., the speed must not change according to whether low or high weights of material are collected in the sample receiver.
c) The electricity supply must be of constant voltage.
d) The brake must be activated after the sample has been collected and not influence the speed by prematurely slowing down the sample collector.

Pneumatic and hydraulic drive systems have been contemplated but in practice it has been found that they do not produce a constant sampling speed.

Dust protection of sampling machines:

If the bulk material contains a large quantity of finely divided powder then precautions must be taken to prevent dust from damaging or influencing the sampler drive mechanism. This can be achieved by

a) Spraying the surrounding area with water to reduce atmospheric dust. Thought must be given to the effect of water on subsequent moisture checks.
b) The sampler can be constructed with extreme care being taken to exclude dust by fitting rubber seals etc. If the sample collector is exposed to dust in the parked position then care must be taken to ensure that the chute does not collect dust prior to its traverse through the falling stream.

Sample weight:

The actual sample weight depends upon many practical considerations. In our experience we have achieved accurate results for sample weight by using the following formula:

$$M = \frac{Q \cdot S}{V \cdot 3600} \text{ (kg)}$$

Where

M = sample weight from 1 passage of the sample collector (kg);
Q = flow rate in t/h;
S = slit width of the sample collector in mm;
V = traversing speed of the sample collector in m/s.

2.2 Comparison of Different Types of Sampling Machines

We describe briefly
here the three most popular types of sample collector.

Spoon Sampler: (Figs. 1 and 2)

It is important with this machine that the volume of the spoon is sufficiently large so that the product is completely contained within the spoon and does not overflow. Normally one designs the spoon so that the volume is equivalent to at least two individual samples as it is often practical to discharge two successive samples at the same time, generally at the starting point of the spoon traverse. The Spoon Sampler is generally unsuitable for sticky materials as emptying of the device in the parked position cannot always be completed without some material remaining on the inner surfaces of the spoon. For these materials the Continuous Discharge Sampler is recommended.

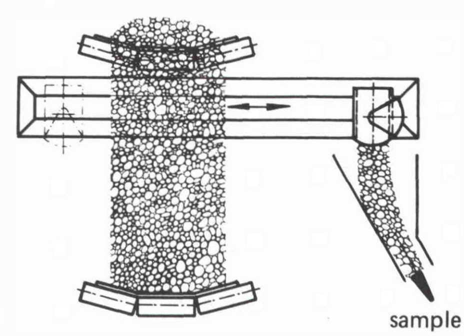


Fig. 1: Schematic view of spoon sampler

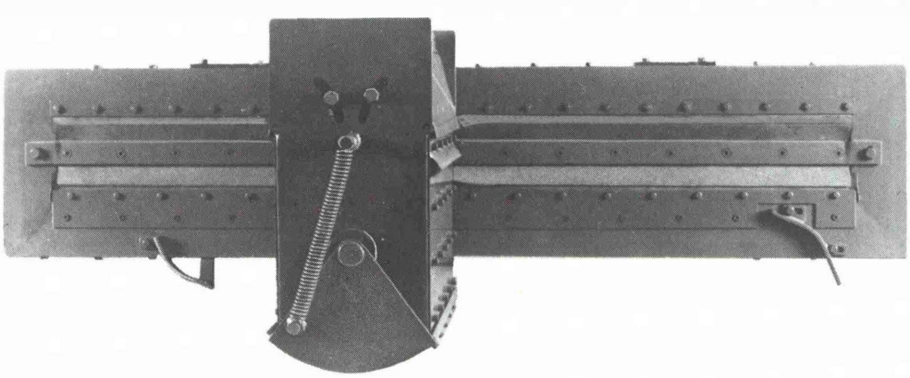


Fig. 2: Type LP spoon sampler

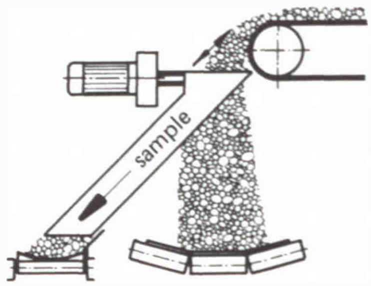


Fig. 3: Schematic view of continuous discharge sampler

Continuous Discharge Sampler: (Fig. 3)

Using this device the sample is continuously discharged onto a small parallel conveyor belt as the sample chute traverses the main product stream. The danger of over-running of the sampler is not present as the material is continuously discharged onto the second conveyor. The depth of the collector must be at least three times the diameter of the maximum particle size so that material cannot rebound out of the collector. The angle of slope of the discharge chute should be a minimum of 50° so that there is no danger of the product collecting inside the device. The inner surfaces of the chute must be completely smooth and rivets, bolt heads etc. should not be permitted. All sharp corners and rough edges should be removed so that cross-contamination of samples is not possible.

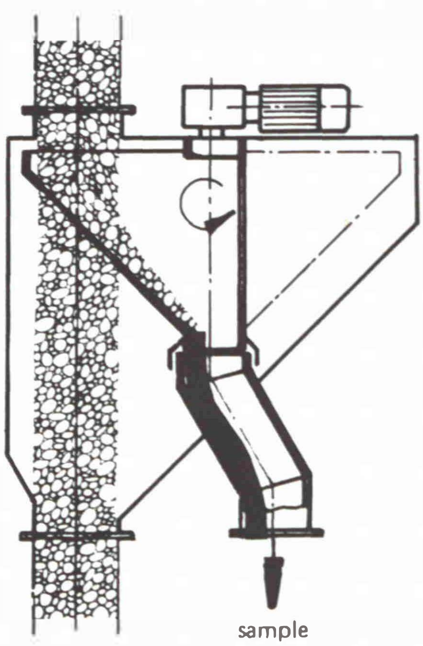


Fig. 4: Schematic view of vertically arranged sampler

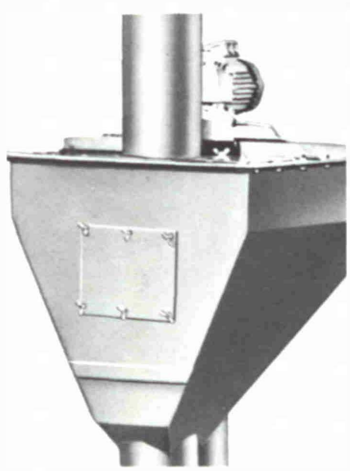


Fig. 5: Sampler for sampling from vertical pipes type SP 40

Sampler for Materials in Vertical Pipes: (Figs. 4 and 5)

This sampler operates by rotating a sample collector through the stream of falling product. The sampler is efficient for sampling the following materials:

a) Powders.
b) Granulate products up to 15 mm diameter.
c) Liquids and waste water.

It is important to state here that the sides of the sample collector should be radial as the peripheral speed of the chute increases with radius and it is possible, with an incorrectly designed chute to sample various parts of the falling stream at speed which could be lower or higher than the optimum. As with the other sampling collectors described, it is important that the sample chute is parked well away from the stream of falling material.

3. Sample Division

The dividing of samples should in principle be accomplished in the same way as the original sample is collected. For top quality work the dividing equipment should yield the final sample made up from many small sub-samples. The sample divider should operate continuously so that one can guarantee that all proportions of the bulk material are subjected to the dividing operation. Only in this way can a fully representative sub-sample be obtained.

Requirements for efficient sample division are:

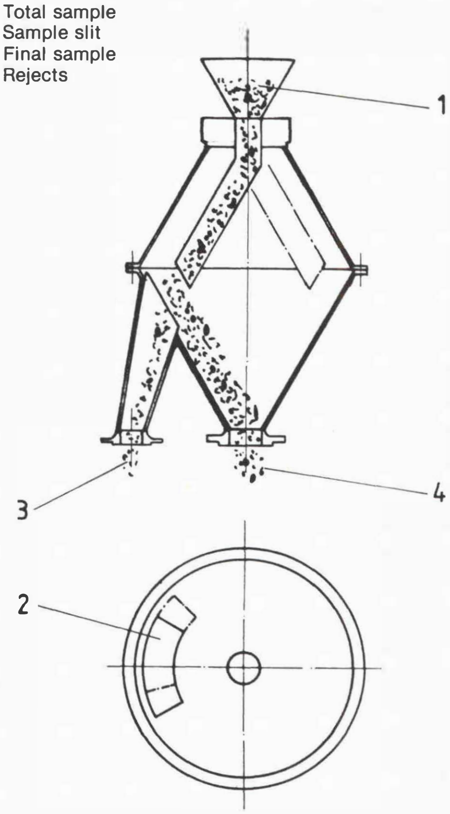
a) The sample should be divided at a steady rate. There should be no danger of the material blocking the divider due to over-size particles or sticky materials.
b) Construction of the machine should be such that cleaning is easy and no rough surfaces should be present so that sample material can be held in the divider.
c) The sample proportion should be adjustable.
d) The machine should be safe and not require frequent servicing.
e) Good access should be available.
f) The machine should be constructed from wear resistant materials.

Fig. 6: Turning-tube divider type PT 35

There are several types of sample divider such as Rifflebox, Plate Divider and Turning Tube Divider. For our discussion we will concentrate on the Turning Tube Divider (Figs. 6 and 7). This type of machine is good for both Laboratory and production purposes and has been used in many applications for many years. Retsch Turning Tube Dividers are available in many sizes and materials and are able to handle particle sizes up to 60 mm.

Fig. 7: Schematic view of turning-tube divider in operation

1. Total sample
2. Sample slit
3. Final sample
4. Rejects



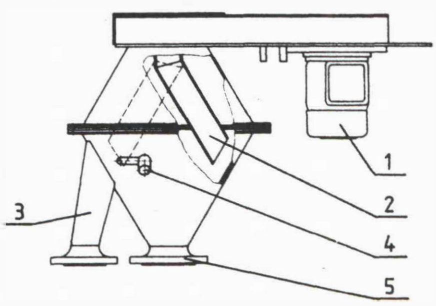


Fig. 8: Turning-tube divider-exploded view

The outer housing of the divider should be dust tight and is generally made from steel sheet of 3 mm thickness. Referring to Fig. 8, we see that the divider is driven, via a drive belt, by a gear motor (1). The total sample is diverted through the turning tube (2) and through the lower conical surface of the divider. An adjustable slit (4) mounted over the sample outlet tube (3) is adjusted to give the proportion of sample required. The remainder, or bulk of the material, passes through outlet (5) whilst the sample is collected from tube (3).

The size of the divider is determined by the maximum particle size present in the material to be sampled and also the desired throughput rate. The most important consideration is the material particle size. The size of the largest particle multiplied by the particle size factor would give the width of the sample slit opening. We recommend therefore to consider carefully the choice of correct particle size factor by taking into account the percentage of the maximum sized particles in the bulk material, see Fig. 9.

Of great importance to representative sample dividing is the correct presentation of the material to the turning tube of the divider. For this purpose we recommend that the material is fed by vibratory feeder through the sample divider, this ensures that a steady flow of product is available rather than intermittent surges which could lead to inaccurate sampling. Fig. 10 shows such a set-up.

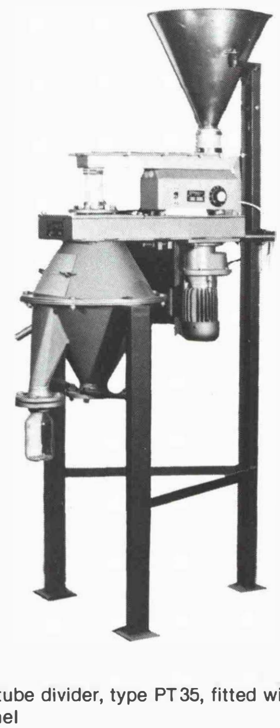
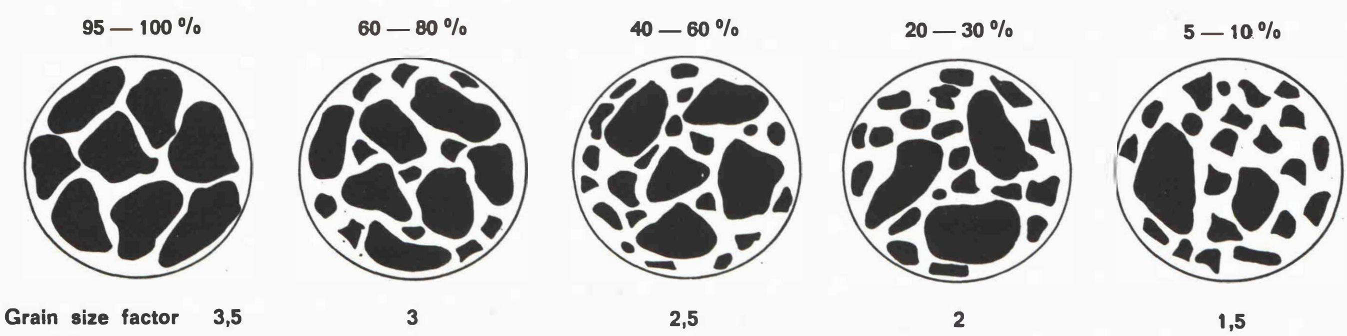


Fig. 10: Turning-tube divider, type PT35, fitted with stand, vibratory feeder and funnel

Fig. 9: Particle size distributions and associated grain-size factors



The speed of rotation of the turning tube is equally important and experience shows that a speed of 0.8 m/s, used in the samplers, should not be exceeded.

One cannot make an accurate statement with regard to individual applications without prior considerations of the various factors involved, e.g., variety of materials to be sampled, particle size of materials, flow capacity etc. In the concrete industry, for example, many applications have been realised and the appropriate information is available. One possibility is for the combined continuous milling and sampling of materials where a mill receives the sample, reduces the material to the acceptable particle size and presents the material in finished form.

4. Conclusions

Today the demand for extracting the maximum from all materials is increasing. Laboratory tests on materials and subsequent economic decisions effecting cost and production require accurate sample taking. Equally important, the purchase of materials without quality control becomes more and more risky. Hence the requirement for efficient sampling.

Satisfactory analysis of materials can only be achieved if the sample has been carefully extracted. It is ludicrous to think of using expensive and sophisticated laboratory and analytical techniques if the sample has not been accurately collected.

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